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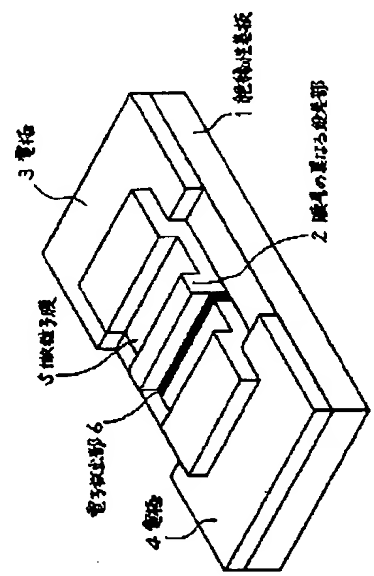
(54)【発明の名称】　電子放出素子及びその製造方法並びに該電子放出素子を用いた画像形成装置

(57)【要約】

【目的】　電子放出部の位置及び形状を制御した表面伝導形電子放出素子及びこれを用いた画像形成装置を提供する。

【構成】　絶縁性基板1上に電極3、4を形成し、さらに一部膜厚の異なる段差部2を設けた微粒子膜5を形成した電子放出素子。

【効果】　上記微粒子膜5に通電処理を施すと、段差部2に沿って電子放出部6が直線状に形成される。このため段差部2の形状を任意に設計することで、電子放出量や電子放出効率等を制御でき、画像形成装置に用いた場合には蛍光体の輝度形状、明るさの均一な画像表示を得ることができる。



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(54) Title of the Invention:

Electron Emitting Device, Manufacturing Method of the Same, and Image Forming Apparatus using Election Emitting Device.

(57) Abstract

[Purpose] The object of the present invention is to provide a surface conduction type electron emitting device in which the position and shape of its electron emission portion are controlled, and an image forming apparatus using the surface conduction type electron emitting device.

[Constitution] An electron emitting device in which the electrodes 3 and 4 are formed on the insulation substrate 1, and further, the fine particle film 5 provided with the step portion 2 is formed, the portion 2 having a thickness different from remaining part.
[Effect] When an electrically conducting processing is performed for the above described fine particle film, the electron emission portion 6 is formed in a shape of straight line along the step portion 2. Thus, by designing the shape of the step portion 2 optionally, quantity of electron emission, electron emission efficiency and the like can be controlled, and in the case of its application to an image forming apparatus luminous shape of phosphor and an image display of uniform brightness can be obtained.

[What is claim is]:
[Claim 1] An electron emitting device comprising a pair of electrodes formed on a substrate, and a fine particle film electrically connected to said pair of electrodes, the improvement wherein said fine particle film has a step portion with film thickness different from remaining part of the film and an electron emission portion is formed nearby the step portion.
[Claim 2] An electron emitting device comprising a pair of electrodes formed on a substrate, and a fine particle film electrically connected to said pair of electrodes, the improvement wherein said electrode partially projects toward an opposed electrode side and at least electron emission portion is formed between the projecting electrode and the opposed electrode.
[Claim 3] An electron emitting device comprising a pair of electrodes formed on a substrate, and a fine particle film electrically connected to said pair of electrodes, the improvement wherein the fine particle film forms a plurality of electron emission portions electrically connected in series and said plural electron emission portions have different electric characteristics.
[Claim 4] The electron emitting device according to claim 3, wherein the electron emitting device has different electric characteristics in electron emission quantity.
[Claim 5] The electron emitting device according to any one of claims 3 and 4, wherein a plurality of electron emission portions are connected in series by an electrode to which a voltage is applicable from the outside.
[Claim 6] A manufacturing method of an electron emitting device comprising

a pair of electrodes formed on a substrate and a fine particle film connecting said pair of electrodes formed on a substrate and a fine particle film connecting said pair of electrodes, the improvement wherein an electrically conducting processing is performed under reducing atmosphere when the electron emission portion are formed by performing the electrically conducting processing for the fine particle film

[Claim 7] An image forming apparatus comprising: an electron source in which a plurality of electron emitting devices according to any one of claims 1 to 5; and an image forming member forming an image by an electron irradiation emitted from the electron source.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] The present invention relates to an electron emitting device used as an electron emission source, more particularly to a surface conduction type emitting device which is one of cold cathode type devices, a manufacturing method of the same, and an image forming apparatus using the relevant device.

[0002]

[Prior Art] Conventionally, as a device which is capable of acquiring electron emission with a simple structure, for example, a cold cathode device which was published by M. I. Elinson et al. has been known (Radio Eng. Electron Phys. Vol. 10, pp. 1290-1296, 1965). Generally, this device is called a surface conduction type electron emitting device, which utilizes a phenomenon in which electron emission occurs by allowing the current to flow in a parallel within a thin film of a small area formed on a substrate.

[0003] As a surface conduction type electron emitting device the following electron emitting devices has been reported. For example, first, the device is formed of a thin film of SnO_2 (Sb) developed by the foregoing Elinson et al. (G. Dittmer: secondly, "Thin Solid Films", Vol. 9. pp. 317, 1992), of an ITO thin film (M. Hartwell and C. G. Fonstad; thirdly, "IEEE Trans. ED Conf.", pp. 519, 1975), of a carbon thin film (Hisashi Araki et al.: and finally, "Vacuum" Vol. 26, No. 1, pp. 22, 1983) and the like.

[0004] Fig. 23 shows a typical device structure of these surface conduction type electron emitting devices. In Fig. 23, reference numeral 231 and 232 denote type electrodes for acquiring electric connection; 233, the thin film

formed of electron emission material; 23 and 4, the substrate; and 235, the electron emission portion.

[0005] conventionally, in these surface conduction type electron emitting device an electron emission portion is formed before electron emission by heat treatment with electrically conducting process called "energization forming". Specifically, the surface conduction type electron emitting device is obtained in such manner that by applying a voltage between the foregoing electrode 231 and the electrode 232, a current flows through a thin film 233, and the thin film 233 is locally broken, deformed, and changed in its quality with a Joule's heat generated by the current flow through the film 233, thus acquiring the electron emission portion 235 being in an electrically highly resistant state.

[0006] It should be noted that an electrically highly resistant state indicates a discontinuity state film having a fissure of 0.5 to 5μ m in a portion of the thin film 233 and having so-called an island structure inside of a fissure. Generally, the island structure indicates an electric continuity state film composed of fine particles provided on the substrate in sizes of diameter from several tens of Å to several μm, and the fine particles indicates a film which is spatially discontinuous and electrically continuous.

[0007] Conventionally, in a case of a surface conduction type electron emitting device, a voltage is applied to the above described highly resistant state film via the electrodes 231, 232, and it makes the current flow on the surface of the device thereby causing the above described fine particles to emit electrons.

[0008] However, there have been the following problems in a device performed "Forming" by the above described conventional heating treatment with electrical conduction.

1) Because Joule's heat generated in a "Forming" step is large, a substrate is prone to be disruptive and device multiplication is difficult.

2) Since the design of the island structure to be electron emission portion is impossible, the improvement of the device is difficult, the variation of performance among devices is prone to generate.

3) Because materials for the island are limited to gold, silver, SnO_2 ITO and the like, and materials with low work function can not be used, large current can not be obtained.

[0009] Since there are the above described problems, although surface con-

duction type electron emitting device has the feature that the structure of the device is simple, surface conduction type electron emitting device has not been applied positively in the concerned industry.

[0010] The inventors of the present invention have taken the above described problems in consideration and investigated, and as a result of that, we proposed a novel surface conduction type electron emitting device in which a fine particle film is arranged between electrodes, and electron emission portion is provided by performing an electrically conducting processing in Japanese Patent Application Number: Showa 63 (1988)-17570, Japanese Patent Application Number: Showa 63 (1988)-110480. Fig. 24 shows a constitutional view of a novel electron emitting device.

[0011] In Fig. 24, reference numeral 241 and 242 denote the electrodes; 243, the fine particle film; 245, the electron emission portion and 244, the substrate.

[0012] As the features of this electron emitting device, the followings are enumerated.

1) Since the electron emission portion 245 is capable of being formed by making a very little current flow into the fine particle film 243, device without device deterioration is produced, and further, a form of electrode can be designed optionally.
2) Because fine particles themselves of which a fine particle film composes are constitutional materials of an electron emission material, the design of a material, a form and the like is capable of being performed, and then the characteristic of electron emission can be changed.
3) The choice of materials of constitutional members of a device like the substrate 244 and electrode is widened.

[0013] Moreover, conventionally, a thin-type image display apparatus exist, in which multiple electron emitting device expanding in a plane and a phosphor target receiving the respective irradiation of electron beam emitted from this electron emitting device are faced each other. These electron beam display apparatuses are fundamentally composed of the following constructions.

[0014] Fig. 25 shows an outline of a conventional display apparatus. Reference numeral 251 denotes the substrate; 252, the supporting body; 253, the device wired electrode; 254, the electron emission portion: 255, the electron passage hole; 256, the modulation electrode; 257, the glass plate; and 258, the

image forming member composing of, for example, phosphor, resist material and the like in which electrons collide each other, whereby emitting light, discoloring, discharging, changing in quality or the like are occurred. And, reference number denotes 259 the luminous spot of a phosphor.

[0015] Hereupon, the electron emission portion 254 is formed by a thin film technology and floats in a space which never touches the glass substrate 251. Whether the device wired electrode 253 may be formed of the same material used for an electron emission member. Alternatively, electrode 253 may be formed of other materials. Generally, a material whose melting point is higher and electric resistance is smaller is used. The supporting body 252 is formed of insulating materials or conducting materials.

[0016] In the above described electron beam display apparatus, a voltage is applied to the device wired electrode 253 and electrons are emitted from an electron emission portion which floats in the space. Then, a voltage is applied to the modulation electrode 256 which modulates these electron flow in accordance with information signals, thereby taking out the electron flow, and the taken-out electrons are accelerated so that the electron collide against the phosphor 258. Furthermore, the XY matrix is formed by the device wired electrode 253 and the modulation electrode 256, thereby displaying an image on the phosphor 258 which is an image forming member.

[0017]

[Subjects to be solved by the Invention] However, in the above mentioned surface conduction type electron emitting device which present and other inventors proposed previously as shown in Fig. 24, the electron emission portion 245 is formed within the fine particle film 243 between electrodes. This electron emission portion 245 is likely to be set on emission location of electrons, but actually, since the electron emission portion 245 is formed in a fine range of 0.01 μm to 0.5 μm , and the deviation of its locations generated due to the formation condition of a fine particle film or the condition of electrically conducting processing or the like, it was difficult to arrange the electron emission portion at a predetermined position precisely.

[0018] In Fig. 24, although the electron emission portion is drawn in linear, but actually, winding its way considerably between the electrode 241 and the electrode 242, the form is rather changed due to the condition of the electrically conducting processing. Therefore, an effective length of the electron

emission portion could not be designed.

[0019] Generally, the distance between the electrode 241 and the electrode 242 is 0.5 μm to 50 μm, but the wider the distance between them is, the more difficult the control of the position of the electron emission portion is.

[0020] For such deviation of the positions of the electron emission portion in the case of application of the electron-emitting devices, they differ in electron emission quantity, more particularly, when these devices were applied as flat electron source comprising plurality of the devices, there was a problem that electron emission quantity varies from place to place.

[0021] As an effective application example of a flat electron source, there is a thin image forming apparatus compressing plural electron "emitting devices" expanded in a flat plane and phosphor targets receiving electron beam irradiation from relevant one of the electron "emitting devices" facing each other respectively, which has been published in Japanese Patent Laid-Open No. S56-23 445. When the above described surface conduction type electron emitting device was applied as electron source of this image forming apparatus, since electron emission quantity of each device was different, brightness of phosphor was different depending on locations, and unevenness of display generated.

[0022] Moreover, in the above described conventional electron emitting device performing electric conducting heating, since a large power was required for the electric conducting heating, the deterioration of electron emission portion and substrate was significant, the property of electron emission and the positions of electron emission portions were not controllable.

[0023] Further, in the case of the above described conventional type surface conduction type electron emitting device or in the case where thermionic electron sources performing with an electric conducting heating was arranged electrically in series, there were the following problems:

1) Making only one portion of multiple electron emission portion connected in series emit electrons is not possible.
2) Due to connection in series, a voltage is divided at each electron emission portion therefore, drive voltage is to be high and consuming power increases.
3) Owing to voltage drop, deviation of the voltage applied to device generates, therefore, quantity of electron emission is not uniform.

[0024] Specifically, an object of the present invention is to provide an electron emitting device which is capable of solving the problems described above, its manufacturing method and an image forming apparatus using the device.

[0025]

[Means and Function for Solving the Subjects] Out of the above described subjects, means taken for solving the problem of controlling the shape of an electron emission portion and its position in the first present inventions is as follows. An electron emitting device comprising a pair of electrodes formed on a substrate, and a fine particle film electrically connected the pair of electrodes, the improvement wherein the fine particle film has a step portion with film thickness different from remaining part of the film and an electron emission portion is formed nearby the step portion, of the improvement wherein the electrode partially projects toward an opposed electrode side and at least electron emission portion is formed between the projecting electrode and the opposed electrode.

[0026] Moreover, means taken in the second present invention for solving the problem in the case where the foregoing multiple electron emitting devices are connected in series is as follows. An electron emitting device comprising a pair of electrodes formed on a substrate, and a fine particle film electrically connected the pair of electrodes, the improvement wherein the fine particle film forms a plurality of electron emission portions electrically connected in series and the plural electron emission portions have different electric characteristics, concretely, different electron emission quantity, and moreover a plurality of electron emission portion of the foregoing electron emitting device are connected in series by an electrode to which a voltage is applicable from the outside.

[0027] Moreover, means taken in the third present invention for solving the problem of lowering of the power required for heat treatment with electric conduction when the foregoing conventional type electron emitting portion is formed is as follows. In a manufacturing method of an electron emitting device comprising a pair of electrodes formed on a substrate and a fine particle film connecting the pair of electrodes, the improvement wherein an electrically conducting processing is performed under a reduction atmosphere when the electron emitting portion is formed by performing the heat treatment with electric conduction emitting portion the fine particle film.

[0028] Constitutional factors and operations of the present invention will be described in detail below.

[0029] As a fine particle film of the present invention, a film formed of conductive fine particles having the diameter of several tens of Å to several μm or a carbon thin film in which these conductive particles are dispersed or the like are included. As materials for these particles, any one of metals such as Pd, Ag, Au, Ti, or any one of conductive materials, for example, oxide of electrically conductive substance such as PdO, SnO_2 will do. And these films are formed between electrodes by gas deposition method or distribution application method.

[0030] Fig. 1 is a constitutional view of device for showing a first embodiment of the first present invention. In Fig. 1, reference numeral 1 denotes an insulation substrate; 2, a step portion with film thickness different from remaining part of the film; 3 and 4, an electrode; and 5, a fine particle film.

[0031] In the above described step portion, with film thickness different from remaining part of the film in an first present invention, the difference between its thickness and that of remaining part of the fine particle film is preferably more than one fine particle diameter, difference of 200 Å to μm is practical and desirable. Moreover, the position, the width and the like of the step portion is not limited in particular if it is formed at the locations between electrodes.

[0032] When an electric conduction processing is performed for a fine particle film having different film thickness in some portions between electrodes as described above, as shown in Fig. 1, the electron emission portion 6 is formed in a shape of straight line along the portion of different film thickness, so that the electron emission portion never meanders unlike the prior arts. These electron emission portions are formed around step portion with film thickness different from remain by part of the film depending on the electric conducting direction, the kinds of fine particle materials, the thickness and shape of fine particle films and the like, on upper side or down side or right side or left side or the like of the step portion with film thickness different from remaining part of the film.

[0033] Fig. 9 is a constitutional view of an element for showing another embodiment of the first present invention.

[0034] In a conventional electron emitting device, a distance G between the

electrodes 3 and 4 is constant through the entire region of an emission width W. However, in this embodiment, by previously providing a section of being prone to further cause electric field concentration between the electrodes, an electron emission portion is formed in a form-fixed and non-continuous manner. For a distance between the electrodes 3 and 4, in the case of a conventional electron emitting device, the distance of 0.1 μm to 100μm is desirable, and generally the distance of 0.5μm to 20μm is practical. However, if an electric field concentration region is provided in the above described manner, the region of 10μm to 100μm is practical.

[0035] Moreover, for a forming method of the above described electric field concentration region, it is easiest that the projection portion (projecting electrode) 101 which more narrows a distance between the electrodes is previously made out in a section of the electrodes 3 and 4 opposing each other as shown in Fig. 10. Since the electron emission portion is formed along this electric field concentration section, in the first present invention, a relation between a distance g between the projection portions 101 and the width w of projection portion 101 is desirably g≦w, concretely, g is practically 0.5μm to 5μm.

[0036] Moreover, the provision of the projection portion 101 at least one location per one electron emission portion can substantially prescribe the electron emission portion. A relation between the pitch P of the projection portion 101 and the distance G between the electrodes 3 and 4 is desirably P<G.

[0037] As described above, by providing electrode projection so as to make a distance between the electrodes narrower, electron emission portion is formed in a shape of straight line, and an electron emission portion never meander as the above described prior art.

[0038] For electric conducting processing methods, there is a method performed in such manner that the fine particle film is partially converted to be highly resistant by the heating with electric conduction, thereby forming the electron emission portion, or there is a method performed in such manner that the fine particle film is partially converted to be low resistant by applying a current to the fine particle film, thereby forming the electron emission portion. Either of the methods will be satisfactory.

[0039] During such the electrically conducting processing, the structure of a fine particle film is changed and the above described discontinuous electron

emission portion is formed. In the first present invention, what kind of role the step portion 2 with film thickness different form remaining part of the film or the projection portion 101 actually plays is not clear. However, the inventors suppose that temperature distribution or electric field distribution is discontinuous at the step portion 2 with film thickness different from remaining part of the film or the projection section 101, whereby an electron emission portion is formed along the step portion or the projection. Consequently, besides the above described method providing the step portion or the projection portion, it is expected that the same effect can be obtained with the provision of the member which makes the temperature and the electric field discontinuous.

[0040] Accordingly, in the first present invention, the configuration of an electron emission portion is changed depending on the shape of the foregoing step portion with film thickness different from remaining part of the film or the projection portion. For example, as shown in the Fig. 1 or Fig. 10, if the shape of the step portion or the projection portion is formed in a shape of straight line, an electron emission portion is also formed in a shape of straight line, therefore, the electron emission portion can be easily put into practice, in which the position and shape of the electron emission portion are controlled.

[0041] An electron emitting device in the first present invention has a constitution in which the shape-determined electron emission portion, the fine particle films putting the electron emission portion therein, the fine particle films being coupled electrically, and the electrode for applying a current to the electron emission portion and the fine particle films are provided. Compared with the prior art, since the shape and position of the electron emitting device can be precisely designed, it is possible not only to control the electron emission characteristic but also to obtain the reproducibility.

[0042] Fig. 15 is a constitutional view showing a second embodiment of the present invention.

[0043] It should be noted that an electron irradiated phosphor target is also shown in Fig. 15.

[0044] In fig.15, reference numeral 154 denotes the phosphor target which is composed of the transparent plate 151, the transparent electrode 152 and the phosphor 153; and 155, the electron irradiation region light (emission section).

[0045] An electron emitting device in the second present invention is consti-

tuted by multiple pieces (in Fig. 15, two pieces) of electron emitting portion electrically connected in series, which corresponds to one electron irradiation region (light emission section).

[0046] In the second present invention, the distance between the electrodes 1 and 2 is preferably 0.1 to 100μm. Generally, 0.5 to 20μm is practical. Moreover, the distance S of the adjacent electron emission portions 6 is preferably 0.5 μm to 2mm, generally, 1μm to 1000μm is practical.

[0047] There are many electrically conducting processing methods of the fine particle film 5 formed of an electron emission material. One of the methods is performed in such manner that the fine particle film is partially converted to be high or low resistant by performing the electrically conducting heating for the fine particle film 5, thereby forming an electron emission portion. However, any method may be used to this invention. By performing the foregoing processings more times at least the number of multiple pieces of the electron emission portion, the structure of the fine particle film formed of all the electron emission materials is changed, and the above described discontinuous electron emission portion is formed.

[0048] Moreover, a driving voltage is applied by the electrode 161 as shown if Fig. 16 to a surface conduction type electron emitting device which has been subjected to the foregoing electrically conducting processing, it is possible to obtain electron emission from the only one electron emission portions among them. It is not clear how actually electron emission from only one portion is possible. The inventors suppose that it is because of the characteristic peculiar to surface conduction type electron emitting device previously proposed as shown in Fig. 24.

[0049] Moreover, as shown in the Fig. 15 and Fig. 16, the electron irradiation region (light emission section) 155 provided by a surface conduction type electron emitting device of the second present invention is formed in a shape similar to an ellipse in which L>W is satisfied because of its characteristics.

[0050] Next, the features of the second present invention will be described using Fig. 16. In Fig. 16, reference numeral 1 denotes the insulation substrate; 3 and 4 and 161, the electrodes; 5, the fine particle film composed of electron emission material; and 6a, 6b, the electron emission portions.

[0051] In Fig. 16, an electron emitting device is composed of two electron emission portions 6a, 6b which are connected in series, furthermore, the volt-

age can be applied to the electrode 161 located between two electron emission portions from the outside. As described above, a potential of the electrode 161 is made undecided and the electrodes 3 and 4 are subjected to an electrically conductive processing, thereby forming an electron emission potion. At this time, at either of two electron emission portions connected in series (for example, the electron emission portion 6b), an electric field concentration occurs, and an electron emission starts.

[0052] At this time, the electron emission portion 6a exhibits a low resistance, and the electron emission portion 6a does not work as an emission portion but as a conductor.

[0053] And on the contrary, when the electron emission portion 6a works as an emission portion, the electron emission portion 6b works only as a conductor.

[0054] Moreover, at the time of driving this device, when the electrode 4 and the electrode 161 are previously short-circuited and, in addition, the electrode 4 is set to an earth potential and the electrode 3 is set to a drive voltage, thereby emitting the electrons, an electron emission from only the electron emission portion 6a occurs. In this state, although the electrode 4 and the electrode 161 are set to an open-state, the electron emission portion is kept on the side of the electron emission portion 6a, and the electron emission is continued.

[0055] And on the contrary to the above description, when the electrode 3 and the electrode 161 are short-circuited and the similar drive is performed, the side of the electron emission portion 6b performes as the electron emission portion

[0056] As described above, in the case where an appropriate voltage is applied to the electrode 161 from the outside and the similar drive is performed, the electron emission portions connected in series can be driven selectively.

[0057] Furthermore, electron emission portions connected in series which is the main feature of the second present invention will be described.

[0058] In the second present invention, the respective electron emission portions connected in series can be driven independently. Making the use of this characteristic, the electric characteristic of each one of the electron emission portions connected in series is previously made different from each other, and by driving any one of the electron emission portions according to the necessity,

the electron emission quantity per one device can be controlled.
[0059] As concrete means for making the characteristic of each one of the respective electron emitting regions different from each other, a method in which the respective width of the electron emission portion is made different by difference of the width of the electrode, or a method in which the width of the electron emission portion is made different by difference of the width of the discontinuous film can be used.
[0060] Next, a manufacturing method of an electron emitting device of a third present invention will be described bellow.
[0061] In the third present invention, there is a method comprising steps of providing a thin film conductor including fine particles between electrodes opposing each other, and an electrically conducting processing is performed for this thin film conductor under the reducing atmosphere. With this method the thin film conductor is reduced, and the electron emitting portion is formed.
[0062] For the above described electrically conducting processing methods, there is a method performed in such manner that the fine particle film is partially converted to be highly resistant by the conducting the heat treatment with flow of electric current thereby forming the electron emitting portion or there is a method performed in such manner that the fine particle film is partially converted to be low resistant by applying a current to the fine particle film, thereby forming the electron emitting portion. Either of the methods will be satisfactory.
[0063] In the third present invention, the thin film conductor is partially reduced by performing an electrically conducting processing under a reduction atmosphere, a voltage is applied to the reduced portion substantially, and a fissure is generated. Accordingly, the electrically conducting processing can be performed in a low power or in a low power or in a short time in comparison with a power consumption conventionally consumed at the time of the electrically conducting processing. Therefore, if the reduction of the thin film conductor can be promoted by any method besides this method, it is expected that the same effect can be obtained. In take third present invention, the reduction atmosphere indicates a gas such as H_2, nitrogen oxide and carbon oxide, or mixed gas of these gases and inert gas such as N_2.
[0064] Next, Fig. 8 shows a schematic constitutional drawing of an image

forming apparatus in which plural electron emitting devices of the first or the second present invention are arranged.

[0065] In Fig. 8, reference numeral 81 denotes the insulation substrate; 82, 83, the electrodes; 84, the fine particles film; and 85, the electron emission portion. The flat electron source 86 is formed by these components.

[0066] A flat electron source of the embodiment is comprised of a plurality of electron emitting devices of the first present invention arranged as shown in fig. 1, in particular several linear electron sources in which electron emitting devices are arranged in parallel between the electrode 82 and the electrode 83 are provided on the substrate regularly.

[0067] Moreover, reference numeral 87 denotes the grid electrode; 88, the electrode passage hole; 89, the glass substrate; 90, the phosphor of image forming member; 91, the metal back formed of aluminum material; 92, face plate; and 93, luminous point of the phosphor.

[0068] The face plate 92 is constituted such that the phosphor 90 is coated uniformly on the transparent glass plate 89, and furthermore, the metal back is provided thereon.

[0069] In this embodiment, the grid electrode 87 is composed of a plurality of line electrode groups and is arranged perpendicular to the electrode groups of the flat electron source 86. The electron passage hole 88 is provided vertically over the electron emission portion 85, and an image is formed by performing the XY matrix drive using the grid electrode 87 as a signal electrode and the line electrode source group as a scan electrode, an image is formed by performing XY matrix drive.

[0070] The above is the description about an image forming apparatus of the present invention. However, as electron beam application apparatus, besides the present invention, there are various kinds of apparatuses such as a recording apparatus, a memory apparatus and an electron beam drawing picture apparatus and the like, and the electron emitting device of the present invention can be preferably utilized for these apparatuses.

[0071] As long as an image forming member is formed of a material which arises emission, changing color, charging, changing quality and deformation by electron beam irradiation emitted from the electron emitting device any material will be satisfactory. As an example, a phosphor a resist material and the like are included. Especially, in the case where a phosphor is em-

ployed as material for the image forming member, an image to be formed is light emission (fluorescent) image.

[0072]

[Embodiment] The present invention will be described further in detail using the embodiment.

[0073] Embodiment 1

Fig. 1 is a constitutional view of a device of this example. Fig. 2 shows an illustration of its manufacturing method.

[0074] Next, the manufacturing method of an electron emitting device of this embodiment will be described below.

[0075] ① The insulation substrate (quartz substrate) 1 is sufficiently cleaned, and the electrodes 3 and 4 are formed using an evaporation technology and photolithography-etching technology normally and frequently used. As a material for the electrodes, any material will be satisfactory if the material has conductivity, but in this embodiment, the electrode was formed of Ni metal. The distance between the electrodes is preferably and practically formed in 0.5 to 20μm. In this embodiment, the gap was formed in 10μm.

[0076] ② Next, organo palladium is dispersed and applied between the electrodes 3 and 4. Organo palladium of CCP-4230 (made by Okuno Pharmaceutical Co., Ltd.) was used. An tape or resist film is provided where fine particles are not to be dispersed, and then the organo palladium is applied by the dipping method or spinner method. Next, by sintering it at 300°C for one hour, the organo palladium is dispersed, and a fine particle film mixed of palladium and palladium oxide is formed. Next, the fine particle film 5 substantially having the uniform thickness was formed at the predetermined position by peeling-off the tape and resist film. for the width of fine particle film, any value of the width is available, but in this embodiment, the width of it was set at 1mm. At this time, the fine particle diameters of palladium and palladium oxide were both 10 to 150Å.

[0077] ③ Next, a palladium film was further applied thereon, and a palladium film was formed so that a fine particle film was formed only at the location where the film should be thickened on the above described particle film using the same method as described above. In this case, the thick film section was set substantially at center section between the electrodes, and a width thereof was set about 2 μm.

[0078] ④ Next, the electrodes 3 and 4 are connected to the power source so that the electrode 3 is one the minus side and the electrode is on the plus side. Then, an electrically conducting processing is performed for the fine particle film 5. As a result, the electron emission portion 6 was formed along the thick film section 2 as shown in the drawing.

[0079] In an electrically conducting processing of this embodiment, the direction of a current flow was set from the electrode 4 side to the electrode 3 side, regardless of the direction of current flow, and the reproducibility was excellent and the electron emission portion can be formed at the above described position.

[0080] When the electron emitting device of this embodiment is compared with the conventional electron emitting device with the particle film having the uniform thickness, substantially the same value was obtained with respect to an electron emission efficiency. Next, the shape of the electron emission portion are compared. Although the electron emission portion of a conventional device meanders with a width of 1mm, in the case of the electron emitting device of this embodiment, the electron emission portion can be formed substantially in a straight line along the step difference which is formed by different film thickness section. Considering its application, it is very important that the position of the electron emission portion can be set precisely. For example, when an electron emitted from the device is deflected and modulated, its control can be performed precisely.

[0081] Embodiment 2

Fig. 3 shows a constitutional view of a device of this embodiment.

[0082] Next, a manufacturing method will be described bellow.

[0083] ① Embodiment 2 is formed with the same materials and method as Embodiment 1-①.

[0084] ② Embodiment 2 is the same with embodiment 1-②.

[0085] ③ Next, palladium film is further coated using the same method as ②, the palladium film was formed so that the fine particle film was formed only at the location where the film should be thickened on the fine particle film. This thick film section was set substantially at center between the electrodes, and the dimensions of the step portion were width (W) of 2 μm, length (L) of 2 μm long, space (S) of 2 μm, and thickness (H) of 200 Å.

[0086] Hereupon, the thickness of fine particle film prior to electrically con-

ducting processing ranges practically from a few score Å to 200 Å, but is not limited to this. It should be noted that the sheet resistance of fine particle film at the time is on the order of 10^3-10^{10} Ω/□.

[0087] ④ Next, the electrodes are connected to the power source so that the electrode 3 is on the minus side and the electrode 4 is on the plus side. Then, electrically conducting processing is performed for the fine particle film 5. As a result, the electron emission portion 6 including the step portion composed of the thick film section 2 is formed substantially in a straight line as shown in Fig. 3.

[0088] This embodiment was studied in the same manner as embodiment 1, resulting in the same effect.

[0089] Embodiment 3

Fig. 4 shows a constitutional drawing of a device of this embodiment.

[0090] Next, the manufacturing method will be described below.

[0091] ① The device of embodiment 3 is formed with the same materials and method as embodiment 1-①.

[0092] ② Embodiment 3 is the same with embodiment 1-②.

③ Next, the palladium film was further applied and the palladium film was shaped so that the fine particle film is formed only at the location where the film should be thickened on the fine particle film using the same method as ②. In this case, the thick film section was set to be in the order of 1/3 of the space between the electrodes.

[0093] ④ Next, the electrodes are connected to the power source so that the electrode 3 is on the minus side and the electrode 4 is on the plus side. then, electrically conducting processing was performed to the fine particle film. As a result, the electron emission portion 6 along the step portion composed of the thick film section 2 was formed as shown in Fig. 4.

[0094] This embodiment was studied in the same manner as embodiment 1, resulting in the same effect.

[0095] Embodiment 4

Fig. 5 shows a constitutional drawing of a device of this embodiment

[0096] Next, the manufacturing method will be described below.

[0097] ① The device of embodiment 4 is formed with the same materials and method as embodiment 1-①

[0098] ② Embodiment 4 is the same with embodiment 1-②.

[0099] ③ Next, the palladium film was further applied, the palladium film was shaped on the fine particle film so that the film was not formed only at the location where the fine particle film should be thinned using the same method as ②. In this case, the thin film section 51 is formed substantially at the center line between the electrodes, having width (W) of 2 μm.

[0100] ④ Next, the electrodes were connected to the power source so that the electrode 3 is the minus side and the electrode 4 is the plus side. Then, electrically conducting processing was performed to the fine particle film 5. As a result, the electron emission portion 6 is formed substantially in a straight line in the groove composed of the thin film section as shown in Fig. 5.

[0101] This embodiment was studied in the same manner as embodiment 1, resulting in the same effect.

[0102] <u>Embodiment 5</u>

Fig. 6 shows a constitutional drawing of a device of this embodiment.

[0103] Next, the manufacturing method will be described below.

[0104] ① The device of embodiment 5 is formed with the same materials and method as ①.

[0105] ② Embodiment 5 is the same with 1-②.

[0106] ③ Next, the palladium film was further applied, and the palladium film was shaped so that the fine particle film was not formed on the fine particle film only at the location where the film should be thinned by the same method as ②. In this case, the thin film section 51 was used as the step difference section which is formed substantially at the center between the electrodes, the step difference section having the width (W) of 2 μm, the length (L) of 2 μm, the distance (S) of 2 μm, and the thickness (H) of 200 Å.

[0107] ④ Next, the electrodes are connected so that the electrode 3 is on the minus side and the electrode 4 is on the plus side, and the electrically conducting processing is performed for the fine particle film 5. As a result, the electron emission portion 6 is formed in a straight line in a groove composed of a thin film section.

[0108] This embodiment was studied in the same manner as in the embodiment, resulting in obtaining the same effect.

[0109] <u>Embodiment 6</u>

Fig. 7 shows a constitutional view of a device of this example.

[0110] In this embodiment, the fine particle film 5 is formed by a gas deposi-

tion method, and the electron emission portion 6 is formed substantially in a straight line with the width of non-fine particle film section 71.

[0111] Next, a manufacturing method will be described bellow.

[0112] ① the device of embodiment 6 is formed with the same materials and method as an embodiment 1-①.

[0113] ② Next, a metal mask is arranged between the electrodes for forming the fine particle film at the predetermined position. The fine particle film 5 comprising the step portion without fine particle film is prepared, the step difference having the width (W) of 2 μm, the length (L) of 2 μm and the distance (S) of 2μm. As a material for this, metals such as Au, Ag, Sn, Pd and the like, or any other conductive fine particles will do, but Pd is used in this embodiment. Meanwhile, the diameter of the particles is 50 to 150 Å. ③ Next, the electrodes are connected to the power source so that the electrode 3 is on the minus side and the electrode 4 is on the plus side. then, the electrically conducting processing is performed for the fine particle film 5. As a result, the electron emission portion 6 is formed within the width of the section 71 without the fine particle as shown in Fig. 7.

[0114] As to this embodiment , the same investigation was carried out in the same manner as an embodiment 1, resulting in the same effect. Moreover, the quantity of electron emission could be controlled by changing the size of the section 71 having not fine particle film, that is, by controlling the size of the electron emission portion formed in the shape of a straight line.

[0115] Embodiment 7

In this embodiment, a plurality of the electron emitting devices of an embodiment 1 are arranged as shown in Fig. 1, and an image forming apparatus is made out as shown in Fig. 8.

[0116] In an image forming apparatus of this embodiment, by the application of a voltage of 14V to the electrode 82 and the electrode 83, the electrons were emitted from the respective electron emission portion 85. Then, by the application of an appropriate voltage to the grid electrode 87, the electrons were drawn out, and the electrons were forced to collide against the phosphor 90 which is an image forming member, and at the same time, a voltage of 500 to 5000V was applied to the phosphor. The present image forming apparatus is, naturally, formed within a vacuum vessel of 1×10^{-5} to 1×10^{-7} Torr.

[0117] In the present experiment, the similar image forming apparatus of

which the thickness of a fine particle film is uniform was compared. Then, the following results were obtained. 1. in the case of this embodiment, since the quantity of electrons emitted from the respective electron emission portion is equal, a display screen with uniform brightness could be obtained. 2. In this embodiment, since the position of the respective electron emission portion was precisely determined, the luminous point 93 of the phosphor was also substantially of the same shape and in regular array.

[0118] Comparing with this embodiment, in the case of the conventional device in which the thickness of fine particle film is uniform and no step portion exists, the shape and pitch of the luminous point differed from place to place.

[0119] Consequently, this embodiment is preferable for acquiring a color picture image and a highly fine picture image.

[0120] Embodiment 8

In this embodiment, an electron emitting device as shown in Fig. 11 was made out as described below. It should be noted that Fig. 11 is a partially enlarged view of a device, and a general view is the same as Fig. 9.

[0121] ① After a resist for list-off was formed on a glass substrate sufficiently degreased and cleaned using usual photolithography technology, the electrode 3 and 4 was formed by vacuum evaporation. The materials used for electrodes were Ti~50Å, Ni~950Å. The electrodes were formed so that the width of electrode is 300 μm and the distance between the electrodes 3 and 4 is 10 μm as shown in Fig. 11 Moreover, the distance between the projection sections 101 added to the electrodes 3 and 4 is 2 μm, the width of the projection 101 is 5 μm, and the pitch of the projection 101 is 10μm.

[0122] ② Next, after Cr thin film~1000Å was formed on the entire electrode substrate formed in ① by vacuum evaporation, only a portion of Cr thin film where the fine particle film 5 is going to be provided was removed by etching.

[0123] Next, after an organic solvent containing organo palladium compound (Catapaste ccp made by Okuno Pharmaceutical Co., Ltd.) was applied in rotation on the electrode substrate obtained until ② stage, sintering was performed at 300°C in the air for ten minutes, and the fine particle film 5 having substantially uniform thickness, which was formed of Pd fine particles, was formed between the electrodes 3 and 4.

[0124] ④ Finally, all of Cr thin film formed in ② stage was removed by etching, and an electron emitting device was completed.

[0125] The electrodes were connected to the power source so that the electrode 3 is on the plus side of the electrode emitting device obtained as above described and the electrode 4 is on earth side or the same. Then, the electrically conducting processing was performed for the fine particle film 5. As a result, the electron emission portion 6 was formed in the shape of a straight line between the projection sections 101 added to the electrodes 3 and 4 as shown in Fig. 11.

[0126] Here, the thickness of fine particle film before the electrically conducting processing is practically from several tens of Å to 200 Å, but there is no limitation to these values. It should be noted that the sheet resistance of the fine particle film is on the order of 10^3 to 10^8 Ω/□.

[0127] In this embodiment, in the electrically conducting processing, the direction of current flow was set from the electrode 3 side to the electrode 4 side. In this embodiment, regardless of the direction of the current flow, the electron emission portion could be formed at the above described positions with an excellent reproducibility.

[0128] Comparative example

As a comparative example, an electron emitting device was formed as shown in Fig. 12. It should be noted that Fig. 12 is a partially enlarged view of device and a general view is almost the same as Fig. 9. In the present comparative example, the width of the electrodes 3 and 4 is 300 μm as in the embodiment 8, but since the projection section 101 is not provided, the space between the electrodes is 10 μm which is constant.

[0129] In the present device, after setting the electrode 3 to be on plus side and the electrode 4 to be on earth side, the electrically conducting processing was performed, the electron emission portion was formed which largely meandered between the electrodes of the distance of 10 μm, as is schematically shown in Fig. 12.

[0130] Moreover, even though other devices were formed in the same manner and the electrically conducting processing were performed for them, the shape of the electron emission portion was not formed with any reproductivity, and variations in the quantity of electron emission among the respective devices were produced.

[0131] Embodiment 9

In this embodiment, an electron emitting device was made out as

shown in Fig. 13. It should be noted that Fig. 13 is a partially enlarged view of device, and a general view is almost the same as Fig. 9.

[0132] In this embodiment, the projection section 101 is provided so as to be opposed to the electrodes 3 and 4, and the space between the electrodes is enlarged to 100 μm. Furthermore, the pitch of the projection section 101 was changed from 50 μm to 1mm variously (Fig. 13 shows one of them).

[0133] Next, a manufacturing method will be described bellow.

[0134] ① After a resist for lift-off was formed on a glass substrate sufficiently degreased and cleaned using usual photolithography technology, the electrodes 3 and 4 is formed by vacuum evaporation. The materials used for the electrodes were Ti~50 Å, Ni~950Å. As shown in Fig. 13, the width of electrode was set to 300 μm and the distance between the electrodes 3 and 4 was set to 100 μm. Moreover, the electrodes 3 and 4 were formed by setting the distance between the projection section 101 added to the electrodes 3 and 4 to 2 μm, the width of the projection section 101 to 5 μm, and the pitch of the projection section 101 to 50 μm to 1mm.

[0135] ② Next, in order to form the fine particle film 5 at the predetermined position on the substrate obtained at ① stage, metal masks were arranged on the electrodes 3 and 4, and the fine particle film 5 was made out by a gas deposition method. The material is metal such as Au, Ag, Ti, Sn Pd and the like. Otherwise, conductive materials could be used. In this embodiment, Pd was used like the embodiment 8.

[0136] The electrically conducting processing was performed for the device obtained as described above in the same manner as the embodiment 8, and the shape of the electron emission potion 6 was observed. As a result, when the pitch of the projection section 101 was up to around 200 μm, an electron emission portion substantially in the shape of a straight line was obtained. However, when the pitch of the projection section is over 200 μm, as shown in Fig. 13, the electron emission portion slightly winding their ways between the projections was observed. The winding of the electron emission portion and also the increase in the emission width emerged, simultaneously.

[0137] However, with respect to the characteristics, some particular and significant deterioration were not observed, and it was understood that the application was possible up to 100 μm of the distance between the electrodes 3 and 4.

[0138] Embodiment 10

In this embodiment, the same image forming apparatus as that of the embodiment 7 in Fig. 11 was made except that a plurality of the electron emission device of the embodiment 8 are arranged and a flat electron source is formed.

[0139] Fig. 14 shows an outline of a constitutional view of an image forming apparatus.

[0140] Also in this embodiment, when a drive experiment was performed in the same manner as an embodiment 7, almost the same results were obtained.

[0141] Embodiment 11

As described below, in this embodiment, an electron emitting device of the second embodiment of the present invention was made out as shown in Fig. 17. Noted that substrate is omitted in Fig. 1.

[0142] ① After a resist for lift-off was formed on a glass substrate sufficiently degreased and cleaned using a usual photolithography technology, the electrodes 3 and 4 and 171, 172 and 173 were formed by a vacuum evaporation. The width (W) of the respective electrode was uniformly 300 μm. The spaces between the electrodes 3 and 171, between the electrodes 171 and 172, between the electrodes 172 and 173, and between the electrodes 173 and 4 were uniformly 2 μm. Moreover, voltages could be applied to all of the electrodes (171, 172, 173) connected in parallel between the electrodes 3 and 4 from the outside, independently.

[0143] ② Next, Cr thin film of 1000Å thick was formed on the entire electrode substrate formed at ① stage except only the portion which forms the fine particle film 5 by vacuum evaporation. That portion is used as a mask for forming the fine particle film 5, and is removed finally.

[0144] ③ Next, after an organic solvent (Catapaste ccp made by Okuno Pharmaceutical Co., Ltd.) containing organo palladium compound was applied in rotation on a substrate obtained until ② stage, sintering at 300 ℃ for ten minutes was performed, the fine particle film 5 formed of a discontinuous film having island structure formed of Pd particles was formed between the electrodes 3 and 4.

[0145] Here, in this embodiment, in order to change the electric characteristic of the respective emission portion, the widths of the fine particle film

formed of an electron emission material are changed. The width of the electron emission portion 6a is 280 μm, 6b is 210 μm, 6c is 140 μm, and 6d is 70 μm.

[0146] ④ Finally, Cr thin film evaporated in ② step was removed by etching, and an electron emitting device was completed.

[0147] The electron emitting device obtained as described above was introduced in a vacuum vessel of on the order of $\sim 10^{-6}$ Torr, and phosphor substrate was provided at the position of 5 mm over the electron emission portion in vertical direction. Then, the following measurements were performed.

[0148] First, the electrode 4 was set to an earth potential, and a voltage of +14V was applied to the electrode 3. Then, an electron emission from the electron emission portion 6a was confirmed at the first application of the voltage.

[0149] Next, after the voltage applied was once restored to the zero, the application was performed again in the same direction as the former application. According to the measurement, it is understood that only light emission corresponding to the electron emission portion 6c was recognized by luminous points of the phosphor unlike the former results.

[0150] After that, even when the direction of the application or the like was changed, the similar change occurs. Specifically, it became clear that an electron emission generated from one of the four electron emission portions connected in series, that is, any one of the plural emission portions was selected at random.

[0151] Moreover, when the voltage drop which was occurring at the respective electron emission portion of the device at the time of electron emission was measured, it was recognized that almost of all the application voltage was applied to only one of the electron emission portion and remaining other respective electron emission portion functioned merely as a conductor.

[0152] Next, when the earth potential was applied to the electrodes 4 and 173, and a voltage of + 14 V was applied to the electrodes 3, 171 and 172, an electron emission from the electron emission portion 6c was confirmed. In addition, the connection of the electrodes 171, 172 and 173 was cut, so that a potential was indefinite, the stage of electron emission was not changed, and an electron emission from the electron emission portion 6c was continued.

[0153] When the same experiment as described above was performed for the

respective electron emission portions 6a, 6b and 6d, it was possible to selectively drive the respective emission portions optionally. Moreover, when the respective electron emission portions were driven, the quantity of electron emission are ~500nA at the electron emission portion 6a, ~350 nA at the electron emission portion 6b, ~200 nA at the electron emission portion 6c, and ~100 nA at the electron emission portion 6d. It could be confirmed that the emission current substantially corresponding to ratio of the width of emission material could be obtained.

[0154] In the electron emitting device manufactured in this embodiment, it was shown that an optional electron emission portion was selectively driven while keeping voltage constant, and a tonal change corresponding to the width of the emission portion could be made.

[0155] Embodiment 12

In this embodiment, an electron emitting device of the second embodiment of the present invention was made out, in which electron emission portions at five different positions were connected in series as shown in Fig. 18. Noted that substrate is omitted in Fig. 18.

[0156] Reference numerals 3 and 4 denote the electrodes for driving the present device; 5, the electron emission material composed of Pd fine particles; 6a to 6e, the electron emission portion connected in series; and 181 to 184, the electrodes connecting the electron emission portions in series, the electrodes being capable of being applied with a voltage from the outside.

[0157] A manufacturing method of device in this embodiment is the same as that of the embodiment 11. However, in this embodiment, in order to change the characteristic of the respective emission portion, the width of electrode corresponding to the respective emission portion was set to 330 μm for the electron emission portion 6a, 240 μm for 6b, 180 μm for 6c, 120 μm for 6d, and 60 μm for 6e. Moreover, all of the respective electrode space in which electron emission portions are formed is constant at 2 μm.

[0158] The electron emission obtained as describe above was housed in a vacuum vessel of ~10^{-6} Torr, and the electrode 4 is set to the earth potential, the electrode 3 is set to 0 to 14V and the electrodes 181 to 184 is made indefinite in potential. And then a current was allowed to flow through the electron emitting device. As already shown in the embodiment 11, since the emission portion located at fine different positions were connected in series,

by at least more than five times of application of the voltage, all of the emission sections at five different positions will possess an electron emission function.

[0159] Next, similar to the embodiment 11, the application of voltages of 0V and 14V was made to both sides electrodes of the driving electron emission portion and to the electrodes 3 and 4, thereby performing an electron emission. For example, in order to make the electron emission portion 6c emit electrons, after the drive is started by setting the electrodes 4 and 183 to the earth potential and the electrodes 3 and 182 to +14 V, when the connection of the electrodes 182 and 183 was cut, electrons were emitted only from the electron emission portion 6c during applying a voltage between the electrode 3 and 4.

[0160] The same operation was performed for all of the emission sections. As a result, it was possible to selectively drive the emission portion optionally.

[0161] Moreover, the quantity of electron emission at the same driving voltage (for example, the electrode 3 is +14V, the electrode 4 is earth potential) were as follows: ~600nA for the electron emission portion 6a; ~450nA for the electron emission portion 6b; ~350nA for the electron emission portion 6c; ~20 nA for the electron emission portion 6d; and ~100nA for the electron emission portion. These values are in proportion to the width of electrodes corresponding to the respective electron emission portion. By selectively driving the electron emission portion in one device optionally, the emission quantity could be changed in steps.

[0162] <u>Embodiment 13</u>

In this embodiment, by arranging a plurality of the electron emitting device of the embodiment 11 as shown in Fig. 17, a flat electron source is formed, and then an image forming apparatus was made out as shown in Fig. 19.

[0163] In this embodiment, as not shown in Fig. 19, and electron emitting device corresponding to a luminous point of a phosphor was composed of electron emission portions connected in series at four different positions. Moreover, the electrodes between the respective electron emission portion are wired so that the electrodes could be applied with a voltage independently from the outside in the same manner as the embodiment 11.

[0164] In the constitution of this embodiment, the electron emission portion at the four positions were constituted such that the widths of the respective

fine particle films thereof were changed and the quantity of current flow emitted was changed depending on the electron emission portion used. Accordingly, the total presentation of the luminous point 93 could be achieved by selectively driving the electron emission portion emitting the required current flow quantity.

[0165] Embodiment 14

In this embodiment, an electron emitting device of the constitution as shown in Fig. 20 was made out by the manufacturing method of an electron emitting device of the third embodiment of the present invention.

[0166] Next, the outline of a manufacturing method of an electron emitting device of this embodiment will be described using Fig. 21.

[0167] ① After the insulation substrate (quartz substrate) 1 is sufficiently cleaned, the electrode 3 and 4 are formed using usually utilized evaporation technology and a photolithography technology. As a material for electrode, anything will do if it has the electric conductivity, however, in this embodiment, the electrode is formed using Ni metal. The electrode space (W) is preferably formed to be 0.5 to 20 μm practically, in the present experimental example, the gap is formed to be 5 μm.

[0168] ② Next, an ITO film was evaporated between the electrodes 3 and 4 by a gas deposition method. Tapes or resist films were provided on the locations where the ITO film should not be evaporated, then, the ITO film was evaporated. Any size of the width of the ITO film will do, however, in this embodiment, the width of ITO film was set to the value of 1mm.

[0169] ③ Next, The electrodes are connected to the power source so that the electrode 3 is on the minus side and the electrode 4 is one the plus side. Then, the electrically conducting processing was performed for the fine particle film 5. The atmosphere at this time was the mixture of 5% concentration of H_2 gas in Ar gas. Conventionally, the Joule's heat of 10 J generated at the "Forming" in the air or the vacuum, in this method, 4 J, that is, 40% of the conventional one. The electron emission portion 6 was formed by this electrically conducting processing.

[0170] In this embodiment, a thin film formed of a fine particle film of the ITO was used, however, a metal fine particle film formed of materials such as gold, silver, or SnO_2 or the like will do, there is no limitation to this. Moreover, in this embodiment, as a film forming method for fine particle film, gas

deposition method was used, but sputtering method or EB method or the like will do, and there is no limitation to this.

[0171] Comparing this embodiment with conventional electron emitting devices, substantially the same value was obtained in electron emission efficiency. Moreover, in the electron emitting device of this embodiment, there is no substrate cracks as seen in conventional device. Furthermore, the electron emission portion could be formed in a shape of straight line at the central section between the electrodes.

[0172] The capability of making out these electron emission portion leads to enhancement of the reproductivity of a device.

[0173] Embodiment 15

An electron emitting device of this embodiment is substantially the same shape as that of an embodiment 14, and is made using SnO_2 for conductive thin film.

[0174] Next, a manufacturing method will be described below.

[0175] ① Embodiment 15 was made with the same materials and method as an embodiment 14-①.

[0176] ② Next, in order to form SnO_2 film at the predetermined position, metal masks were arranged on the electrodes, and then, SnO_2 film was formed by a gas deposition method. Moreover, the film thickness of this thin film was 300 to 500 Å.

[0177] ③ Next, the electrodes were connected to the power source so that one of the electrodes was on the minus side and another electrode was on the plus side. then, the electrically conducting processing was performed. The electrically conducting processing was performed while flowing H_2 gas of 5 SCCM in a vacuum.

[0178] As a result, the energization with 5 J can be available instead of previously the energization forming with 20 J, thereby forming the electron emitting region was formed.

[0179] This embodiment is studied in the same manner as an embodiment 14, resulting in the same effect as that of the embodiment 14.

[0180] Embodiment 16

An electron emitting device of this embodiment has substantially the same shape as that of the embodiment 14 and 15, however, is made out using a fine particle film mixed palladium and palladium oxide as a conductive thin

film.

[0181] Next, a manufacturing method of this embodiment will be described below.

[0182] ① The insulation substrate (quartz substrate) was sufficiently cleaned, then, an electrode was formed using the evaporation technology and photo-lithography technology widely used. In this embodiment, an electrode was formed using Ni metal as an electrode material, and the space between electrodes was a gap of 5 μm.

[0183] ② Next, organo palladium was dispersed and applied between the electrodes. For an organo palladium, Okuno Pharmaceutical Co., Ltd. CCP-4230 was used. Tapes or resist films were provided at the locations were fine particles should not be dispersed. Then, the organo palladium was applied by a dipping method or a spinner method. Next, after baking at 300°C for one hour, the organo palladium was dispersed, and a fine particle film was formed of mixture of palladium and palladium oxide. Next, a fine particle film was formed in the width of 1 mm at the predetermined position by peel-off tapes or resist films. At this time, both of the diameters of fine particles of palladium and palladium oxide were 10 to 150 Å.

[0184] Here, the thickness of fine particle film before the electrically conducting processing ranges practically from several tens of Å to 200 Å, but no limitation to this. Is should be noted that at this time, sheet resistance on the order of 10^3 to 10^{10}切/□. Moreover, it is considered that the thickness of fine particle film is substantially uniform between the electrodes.

[0185] ③ Next, the electrodes were connected to the power source so that one of the electrodes was on the minus side and the other was on the plus side. Then, the electrically conducting processing was performed for the fine particle film. The electrically conducting processing was performed at this time by flowing of H_2 gas of SCCM in a vacuum. As a result, compared with the conventional method which requires 1 second for the electrically conducting processing, this method can perform the electrically conducting processing in a short time of 100 msec, thus forming the electron emitting portion.

[0186] Moreover, the electron emitting portion was formed substantially at the canter section between the electrodes with an excellent reproductivity.

[0187] <u>Embodiment 17</u>

Fig. 23 shows a conventional surface conduction type electron emit-

ting device, however, in this embodiment, the electrically conducting processing was performed for this device.

[0188] In this embodiment, a thin film formed of the electron emission material is a mixture of lead oxide and lead.

[0189] The power source was connected between the electrodes 231 and 232, and the electrically conducting processing was performed for the thin film 233. The electrically conducting processing was performed at this time by flowing mixture of 1 % concentration of H_2 gas in N_2 gas.

[0190] Conventionally, the electrically conducting processing was performed in the air or in a vacuum, since the film was peeled-off or the positions of electron emitting portion could not be controlled, a device having electrically excellent characteristic could not be made out. However, according to this embodiment, the electron emitting portion was formed substantially at the center between the electrodes, substantially in a shape of a straight line of a certain width, and the device having an excellent electric characteristic could be made out.

[0191] Embodiment 18

In this embodiment, the electrically conducting processing was performed for device in the same manner as the embodiment 17 as shown in Fig. 23.

[0192] In this embodiment, a thin film formed of the electron emission material is SnO_2.

[0193] The electrodes were connected to the power source so that one of the electrodes was on the minus side and the opposite electrode was on the plus side. Then, the electrically conducting processing was performed for the SnO_2 thin film 233. The electrically conducting processing was performed at this time by flowing mixture of 1% concentration of H_2 gas in a vacuum.

[0194] In the conventional methods, due to Joule's heat generated during the electrically conducting processing, substrate cracks and the like occurred. However, according to this embodiment, without any problem, the device could be formed with an excellent reproductivity.

[0195] Embodiment 19

In this embodiment, a plurality of electron emitting device of an embodiment 16 were arranged, and a two-dimensional arrayed electron source was formed. Then, the same image forming apparatus as that of the embodiment 7 was made out.

bodiment 7 was made out.

[0196] Fig. 22 shows an outline of a constitutional view of the image forming apparatus of this embodiment.

[0197] In the image forming apparatus of this embodiment, by the application of voltage of 14 V to the electrode 82 and the electrode 83, electrons are allowed to be emitted from the respective electron emitting portion 85, and the electrons were drawn by the application of an appropriate voltage to the grid electrode 87, and the electrons are made to collide against the phosphor 90 of an image forming member, and at the same time, voltage of 500 to 5000 V is applied to the phosphor 90.

[0198] In this embodiment, the electrically conducting processing was performed in the reducting atmosphere, however, after energization forming process, naturally, inner side at the image forming apparatus is placed under the condition of vacuum degree of 1×10^{-5} Torr to 1×10^{-7} Torr.

[0199] When these multi-devices are made out, if the electrically conducting processing is performed in the air or in a vacuum as conventional examples, a high voltage was required for the energization forming process. Therefore, a great deal of heat was generated, so that substrate cracks was occurred. So the devices having an excellent reproductivity could not be mass-produced, and a shape and a brightness of the luminous spot were different from place to place. Comparing with image forming apparatus of conventional ones, the image forming apparatus in this embodiment achieved the following effects:

1. In this embodiment, since quantity of electrons emitted from the respective electron emitting portion was equal, a display screen with an uniform brightness could be obtained.
2. In this embodiment, since the position of the respective electron emitting portion is determined substantially in precision, the luminous points on the phosphor were also substantially of the same shape, and arranged regularly.

[0200] From these points, this embodiment is preferable to obtain color image and high fine image.

[0201]

[Effect of the invention]

As described above, according to the first embodiment of the present invention, an electron emission portion having the shape determined can be

formed, moreover, the first embodiment of the present invention exhibits the following effects, as an electron emitting device or an image forming apparatus:

[0202] 1. the electron characteristics such as an electron emission quantity and an electron emission efficiency and the like can be controlled, and further, the device with less characteristic variations among the devices can be manufactured.

[0203] 2. As an image forming apparatus, an image display of uniform emission luminance is obtained.

[0204] 3. Since the position of electron emission portion are determined precisely, an image display of uniform shape of luminous points of a phosphor is obtained as an image forming apparatus.

[0205] 4. Since an electron emission portion is determined precisely, the shape design and control system of modulation electrode can be performed easily as an image formation device.

[0206] Moreover, according to the second embodiment of the present invention, the electrodes to which a plurality of electron portions are connected in series can be applied with a voltage from the outside, and the characteristic of the respective electron emission portion connected in series are changed previously, whereby the following effects are obtained.

[0207] 5. It is possible to drive only one of electron emission portions in spite of the serial connection.

[0208] 6. Any one of electron emission portions connected in series can be driven optionally.

[0209] 7. By changing the characteristic of the respective electron emission portion previously, the electron emission quantity can be changed in steps.

[0210] 8. Repair in failure is not required.

[0211] 9. Long life is possible.

[0212] Moreover, the electron emitting device made by the third embodiment of the present invention or the image forming apparatus using the same has effects as follows.

[0213] 10. since the electrically conducting processing can be performed at low power, it is possible to manufacture the electron emitting device and multiple electron sources without any destruction of substrate.

[0214] 11. Since the reproductivity is enhanced, the electron emitting devices

and multiple electron sources without any deviation among devices and multiple electron sources without any deviation among devices can be manufactured.

[0215] 12. Since the position of an electron emission portion can be formed substantially at the center section between electrodes, as an image forming apparatus, an uniform shape of luminous points of phosphor and a brightness of uniformity can be obtained.

[Brief Description of the Drawings]

[Fig. 1] This is an outline of a constitutional view of an electron emitting device example of a first embodiment of the present invention.

[Fig. 2] This is a view of illustrating a manufacturing method of an electron emitting device of Fig. 1.

[Fig. 3] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 4] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 5] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 6] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 7] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 8] This is an outline of a constitutional view of an image forming apparatus made out using a plurality of electron emitting device of Fig. 1.

[Fig. 9] This is a general constitutional view of illustrating features of an electron emitting device of a first embodiment of the present invention.

[Fig. 10] This is a constitutional view of an electron emission portion for illustrating features of an electron emitting device of the first embodiment of the present invention.

[Fig. 11] this is a constitutional view of an emission portion showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 12] This is a constitutional view of an emission portion made in the comparative example.

[Fig. 13] This is a constitutional view of an emission portion showing an ex-

ample of a electron emitting device.

[Fig. 14] This is a constitutional view of an image forming apparatus made using a plurality of electron emitting device of Fig. 11.

[Fig. 15] This is an illustrating view of features of an electron emitting device of a second embodiment of the present invention.

[Fig. 16] This is an illustrating view of features of an electron emitting device of a second embodiment of the present invention.

[Fig. 17] This is a constitutional view of an emission portion showing an example of an electron emitting device of the second embodiment of the present invention.

[Fig. 18] This is a constitutional view of an emission portion showing an example of an electron emitting device of the second embodiment of the present invention.

[Fig. 19] This is a constitutional view of an image forming apparatus made out using a plurality of electron emitting device of Fig. 17.

[Fig. 20] This is an outline of a constitutional view showing an example of an electron emitting device made by a manufacturing method of a third embodiment of the present invention.

[Fig. 21] This is an illustrating view of a manufacturing method of an electron emitting device of Fig. 20.

[Fig. 22] This is an outline of a constitutional view of an image forming apparatus using a conventional-type electron emitting device.

[Fig. 23] This is a constitutional view of an electron emitting device made out by a conventional heating method with electrically conduction.

[Fig. 24] This is a constitutional view of an electron emitting device which is made out by a thin film conductor including a conventional fine particle film and fine particles for which an electrically conducting processing is performed.

[Descriptions of the Reference Numerals]

1 insulation substrate

2 step portion

3 and 4 electrodes

5 fine particle film

6, 6a～6e electron emission portion

51 thin film section

71 portion without fine particle film

81 insulation substrate
82 and 83 electrodes
84 fine particle film
85 electron emission portion
86 face-like electron sources
87 grid electrode
88 electron passage hole
80 glass plate
90 phosphor
91 metal back
92 face plate
93 luminous point of phosphor
101 projection section (projected electrode)
151 transparent plate
152 transparent electrode
153 phosphor
154 phosphor target
155 electron irradiation region (emission section)
171 to 173 electrodes
181 to 184 electrodes

[Document for Amendment]
[Date of filing] H5-2-16 (February 16, 1993)
[Amendment of Proceedings 1]
[Name of Document to be Amended] Specification
[Name of Item to be Amended] Brief description of the drawings
[Amendment Method] Changing
[Amendment Contents]
[Brief description of the drawings]
[Fig. 1] This is an outline of a constitutional view showing an example of an electron emitting device of a first embodiment of the present invention.
[Fig. 2] This is an illustrating view of a manufacturing method of an electron emitting device of Fig. 1.
[Fig. 3] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.

[Fig. 4] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.
[Fig. 5] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.
[Fig. 6] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.
[Fig. 7] This is an outline of a constitutional view showing an example of an electron emitting device of the first embodiment of the present invention.
[Fig. 8] This is an outline of a constitutional view showing an imaging formation device made out using a plurality of electron emitting devices of Fig. 1.
[Fig. 9] This is general view of a constitution for illustrating the features of an electron emitting device of the first embodiment of the present invention.
[Fig. 10] This is a constitutional view of an electron emission portion for illustrating the features of an electron emitting device of the first embodiment of the present invention.
[Fig. 11] This is a constitutional view of an view of emission portion for showing an example of an electron emitting device of the first embodiment of the present invention.
[Fig. 12] This is a constitutional view of an emission portion of an electron emitting device made out in the comparative example.
[Fig. 13] This is a constitutional view of an emission portion for showing an example of an electron emitting device of the first embodiment of the present invention.
[Fig. 14] This is an outline of a constitutional view of an image formation device made out using a plurality of electron emitting device of Fig. 11.
[Fig. 15] This is an illustrating view of the features of an electron emitting device of a second embodiment of the present invention.
[Fig. 16] This is an illustrating view of the features of an electron emitting device of the second embodiment of the present invention.
[Fig. 17] This is a constitutional view of an emission portion for showing an example of an electron emitting device of the second embodiment of the present invention.
[Fig. 18] This is a constitutional view of an emission portion showing an example of an electron emitting device of the second embodiment of the present invention.

[Fig. 19] This is an outline of a constitutional view of an image forming apparatus made out using a plurality of electron emitting device of Fig. 17.
[Fig. 20] This is an outline of a constitutional view for showing an example of an electron emitting device made out by a manufacturing method of a third embodiment of the present invention.
[Fig. 21] This is an illustrating view of a manufacturing method of an electron emitting device of Fig. 20.
[Fig. 22] This is an outline of a constitutional view of an image forming apparatus using a conventional-type electron emission element.
[Fig. 23] This is a conventional view of an electron emitting device made out by a conventional heating method with electrically conduction.
[Fig. 24] This is a conventional view of an electron emitting device made out by electrically conducting processing performed or a thin film conductor including a conventional fine particle film and fine particles.
[Fig 25] This is an outline of a constitutional view of a conventional display device.

Continued from the Front Pate
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(72) Inventor: Hidetoshi Suzuki
30-2, 3-Chome, Shimojaruko, Ohta-Ku, Tokyo Canon Inc.
(72) Inventor: Tetsuya Kaneko
30-2, 3-Chome, Shimojaruko, Ohta-Ku, Tokyo Canon Inc.
(72) Inventor: Kei Noma
30-2, 3-Chome, Shimojaruko, Ohta-Ku, Tokyo Canon Inc.

FIG. 1

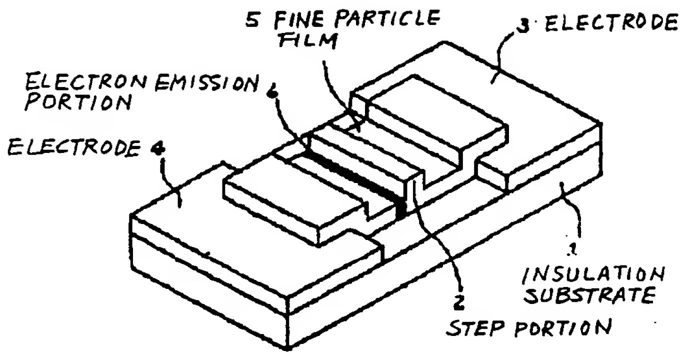


FIG. 2

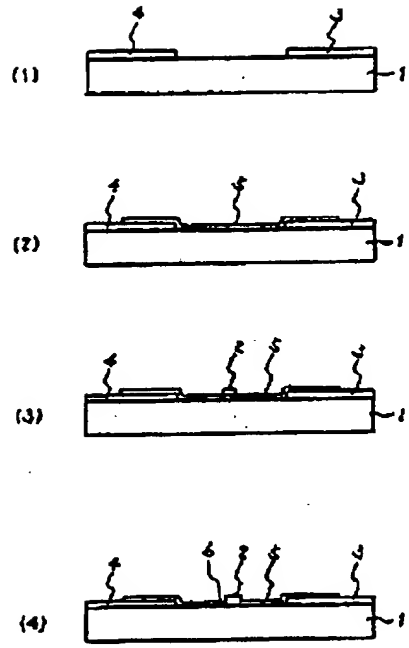


FIG. 3

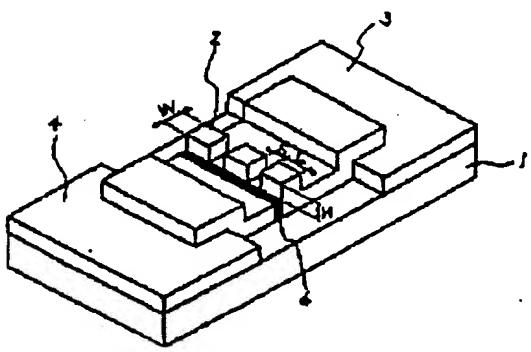


FIG. 4

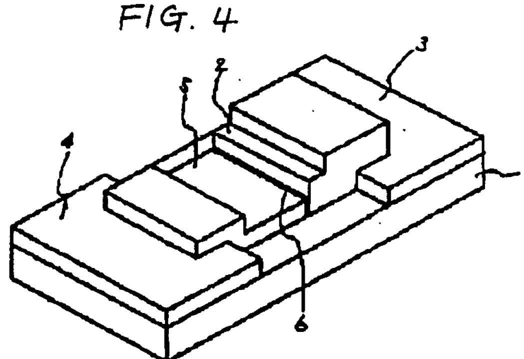


FIG. 9

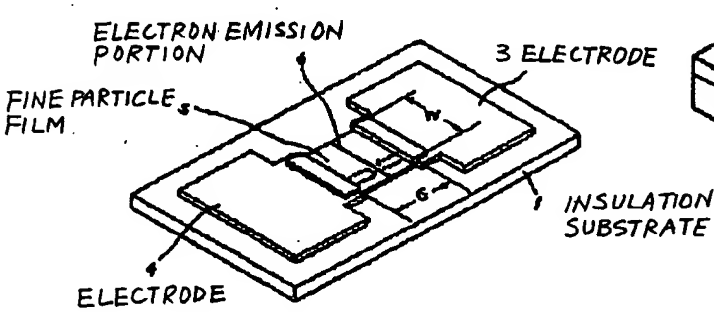


FIG. 5

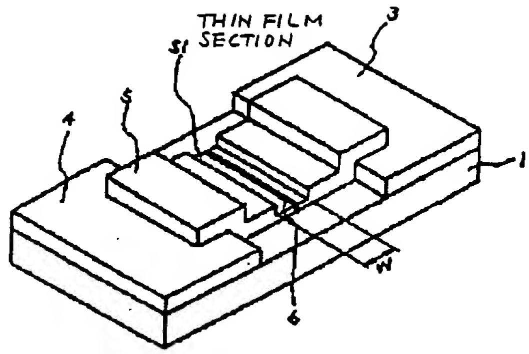


FIG. 6

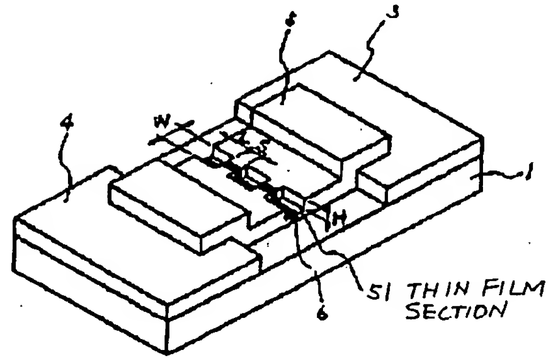


FIG. 7

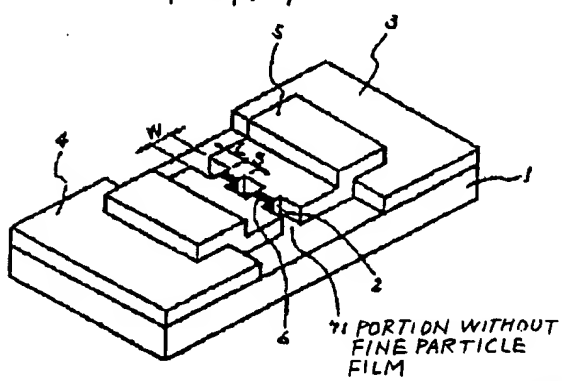


FIG. 8

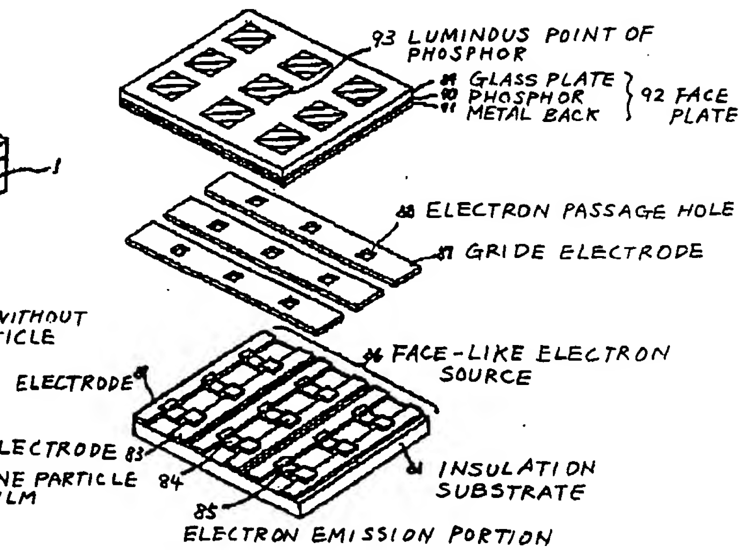


FIG. 10

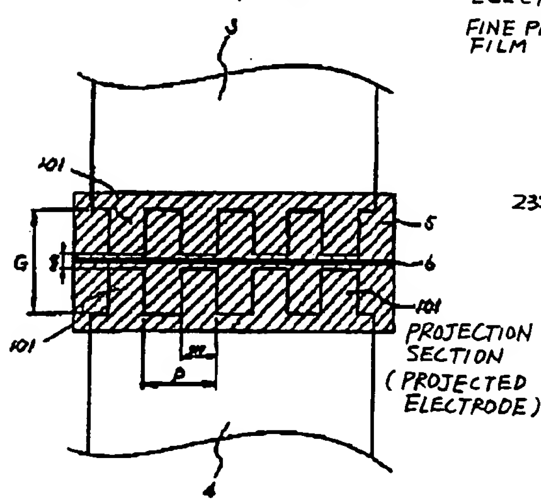
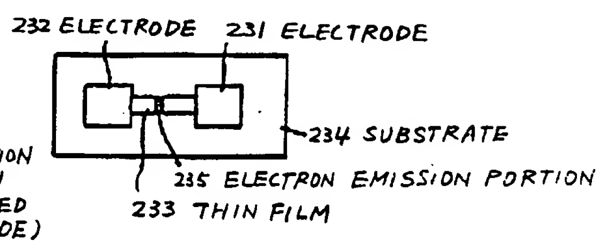


FIG. 23



A TYPICAL CONSTITUTION OF ELECTRON EMITTING DEVICE

FIG. 11

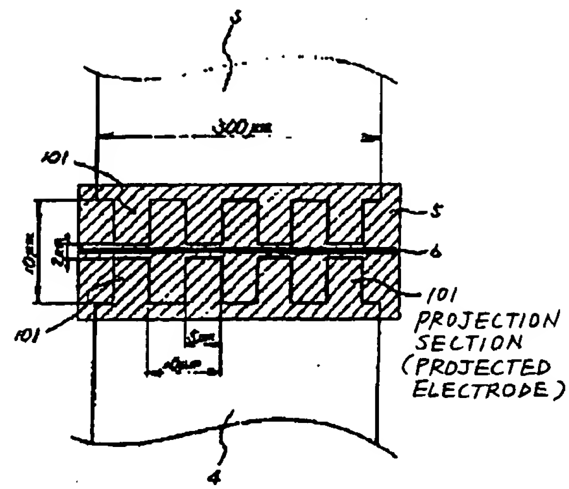


FIG. 12

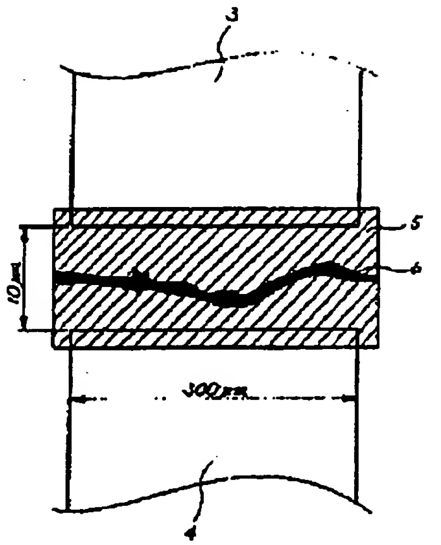


FIG. 13

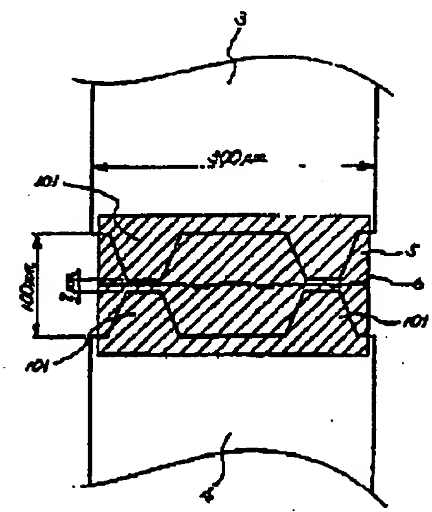


FIG. 14

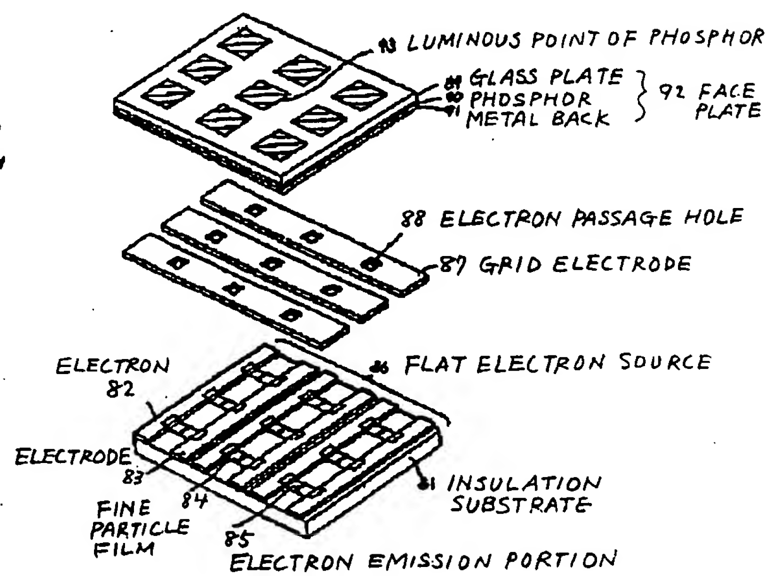


FIG. 24

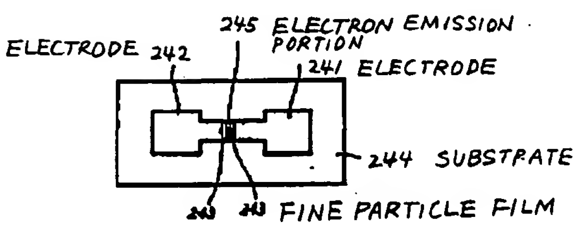


FIG. 15

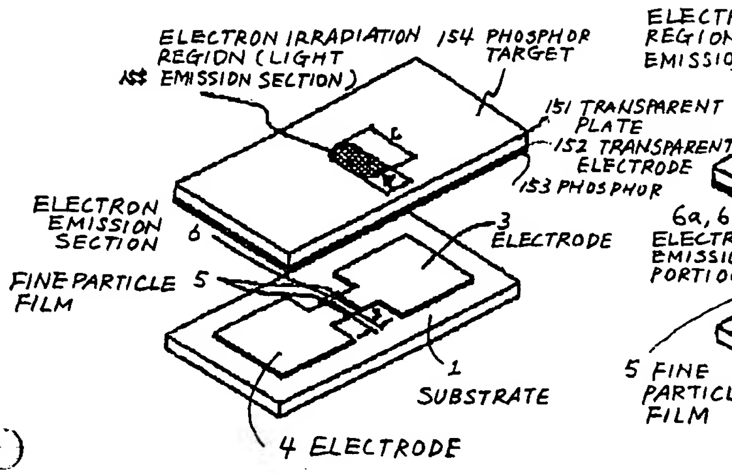


FIG. 16

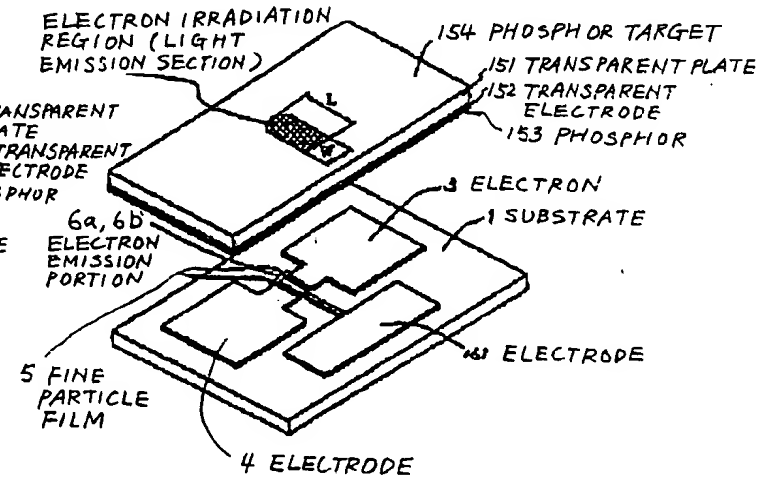


FIG. 17

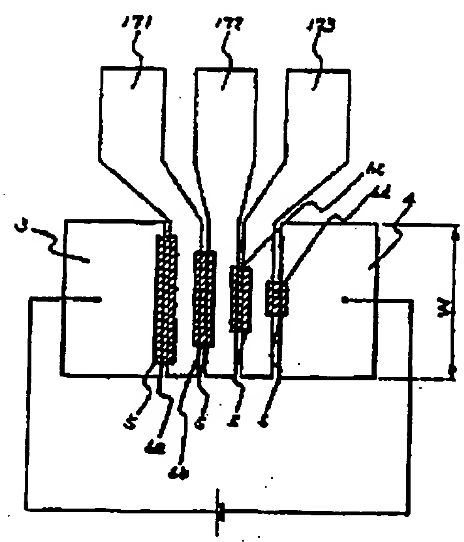


FIG. 18

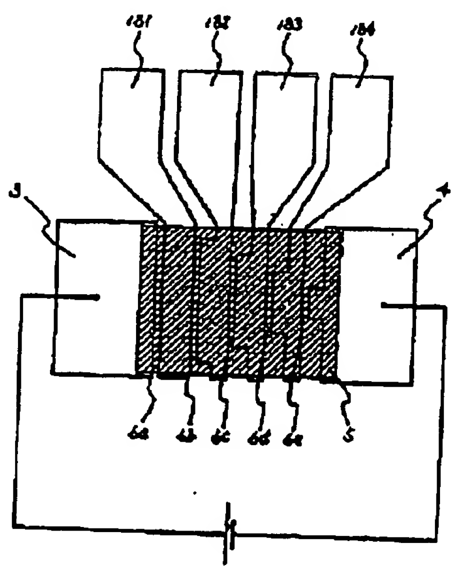


FIG. 19

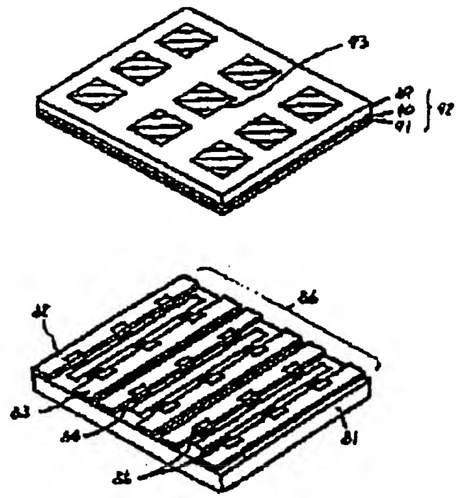


FIG. 20

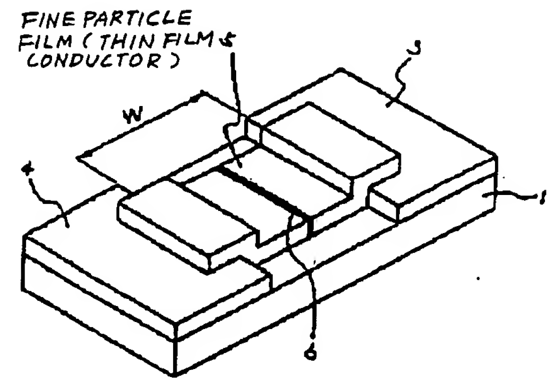


FIG. 21

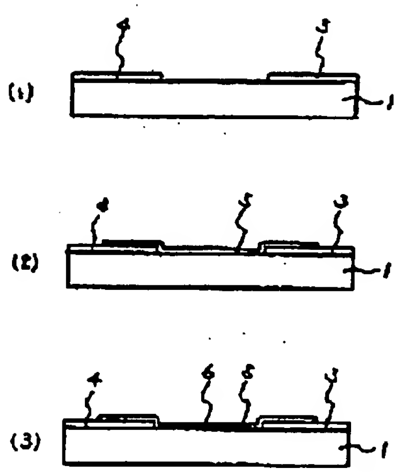


FIG. 22

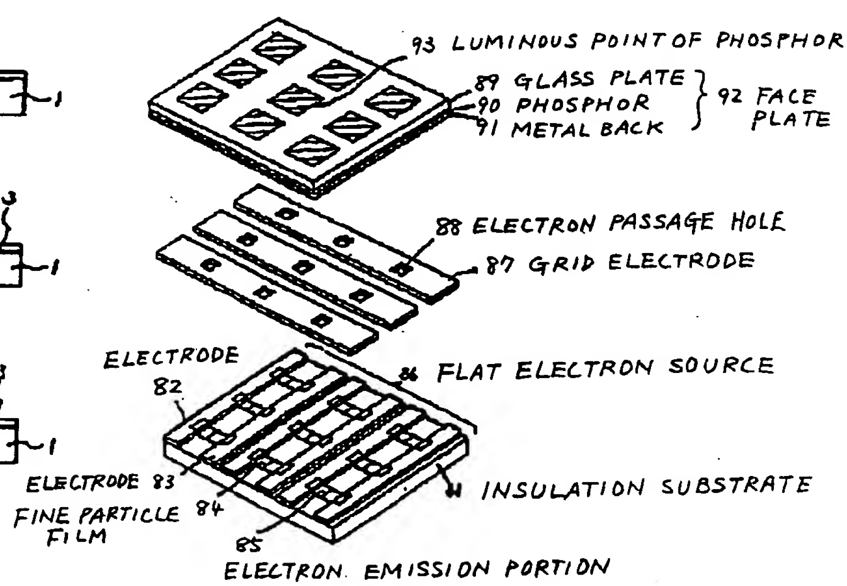
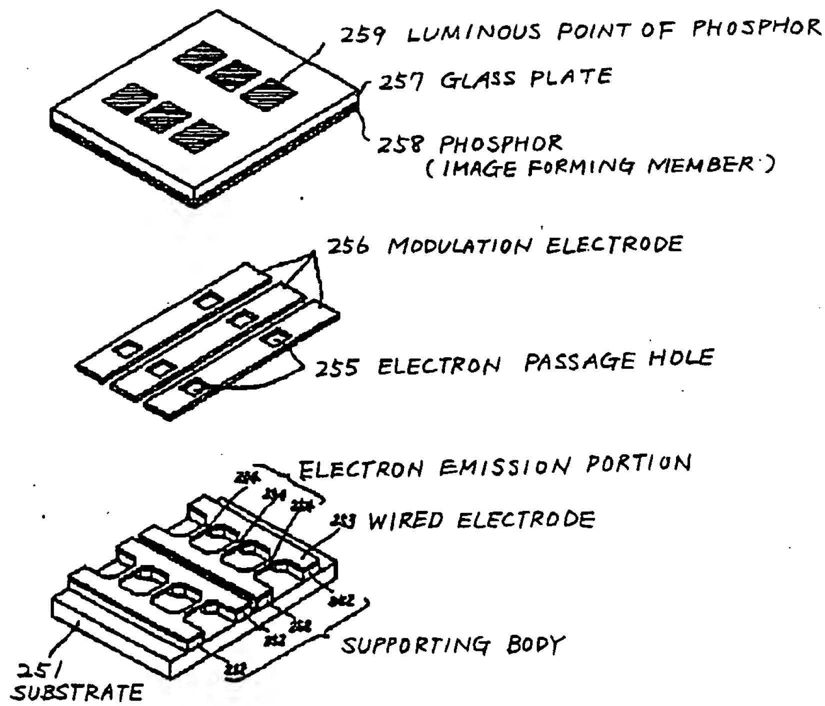


FIG. 25


259 LUMINOUS POINT OF PHOSPHOR
257 GLASS PLATE
258 PHOSPHOR
(IMAGE FORMING MEMBER)
256 MODULATION ELECTRODE
255 ELECTRON PASSAGE HOLE
ELECTRON EMISSION PORTION
WIRED ELECTRODE
SUPPORTING BODY
251
SUBSTRATE